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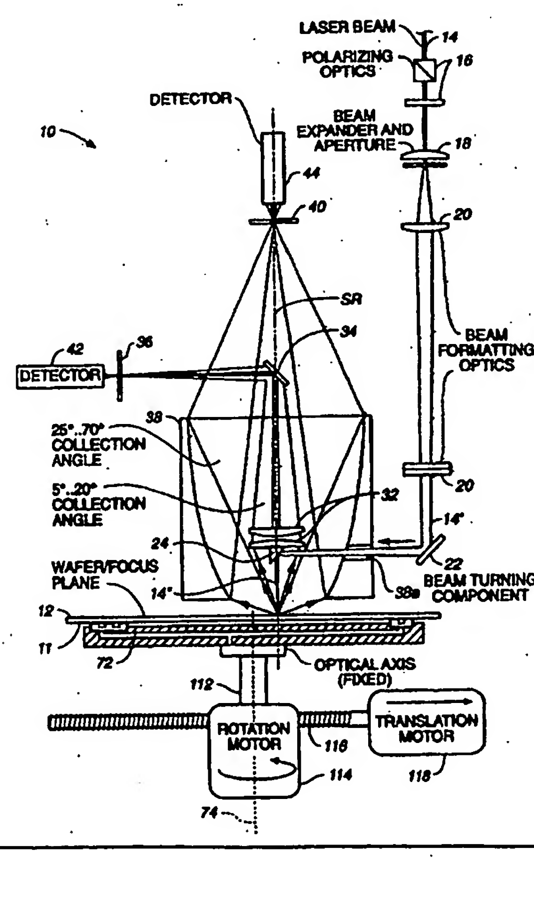
(54) Title: IMPROVED SYSTEM FOR SURFACE INSPECTION

(57) Abstract

A light beam is directed towards a surface (12) along a direction normal to the surface (12). There is a scanning means (114, 116, 118) which causes the surface (12) to move so that the beam scans the surface (12) along a spiral path. Light scattered by the surface (12) within a first range of angles is collected by a first collection means (32, 34) and directed to a first detector (42), and light scattered within a second range is collected by a second collection means (38) and is directed to a second detector (44). The two ranges of collection angles are different, so that the first detector (42) is optimized to detect scattering from large particles, and the second detector (44) is optimized to detect light from small particles and defects.



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# IMPROVED SYSTEM FOR SURFACE INSPECTION

## Cross-Reference to Related Application

The present application is related to U.S. Patent Application Serial No. 08/216,834, entitled "Process and Assembly for Non-Destructive Testing of Surfaces," filed March 24, 1994, hereinafter referred to as "Related Application."

## Background of the Invention

This invention relates in general to systems for surface inspection, particularly those of importance in the semiconductor manufacturing industry, and in particular, to a surface inspection system employing stationary illumination and/or collection systems and two or more detectors.

To detect defects and contamination on semiconductor process surfaces, laser based scanners have traditionally been used due to the high sensitivity afforded by scattered (diffused) light measurements. Two basic types of conventional scanning methodologies have been used. In a first type, surface scanners employ fixed (stationary) illumination and/or collection systems. In the second type, a moving light path (fan) is used, such as that derived from a galvanometric mirror scanner or rotating polygon light beam deflector. The second type of system employs extraneous optical components to effect light deflection and has several major drawbacks. The most significant drawback of the second type system is the lack of rotational symmetry,

both for illumination and collection, imposed by a two-dimensional linear scanned line. This results in unavoidable non-uniformities in the detection and characterization of the defects/particles in question. Other drawbacks of systems of the second type, include the inherent complexities of additional beam forming/shaping optics and moving optical surfaces, as well as the higher stray light background levels that result, thus limiting attainable signal-to-noise ratios.

A number of laser based scanners employing fixed illumination and collection systems of the first type have been disclosed, for example, in U.S. Patent Nos. 4,391,524, 4,526,468 and 4,598,997, all issued to Steigmeier et al. Another type of laser based scanners, employing stationary illumination and collection systems is in U.S. Patent No. 5,377,001 and in the Related Application referenced above. The common feature in the above-referenced patents and application is that the illumination system and the light collection and detection system are stationary and the surface to be inspected is moved along a spiral path. A spiral scan path is accomplished by rotating the surface about a shaft or axle by a rotary motor, and simultaneously translating the shaft or axle along a line using a linear translation stage and motor combination. The rotational motion of the surface about the shaft or axle, and the translational motion of the shaft or axle are coordinated by controlling the two motors so that the illuminated portion of the surface traces a spiral path on the substrate.

## Summary of the Invention

This invention is based on the observation that larger particles scatter light at smaller angles to the direction of the specularly reflected beam, compared

to smaller particles, and the light scattered by the smaller particles is lower in intensity compared to the light scattered by larger particles or defects. In prior art systems where the illumination system and the collection and detection system are stationary, light scattered in a range of angles covering the collection angles for both large and small particles is collected and directed to a single detector means. Therefore, if the detector means is optimized for detecting the low intensity light scattered by smaller particles, the detector means may become saturated by the high intensity light scattered by larger particles. On the other hand, if the detector means is optimized for detecting the high intensity light scattered by larger particles, it is not optimized to detect low intensity light scattered by the smaller particles.

Furthermore, the surface texture itself produces a certain amount of diffracted light in addition to the light scattered by particles. This surface light scatter, commonly referred to as haze, tends to be concentrated at smaller angles near the specularly reflected light beam. If a single detector arrangement is used to detect scattered light from both large and small particles or defects, the effect of haze is to significantly degrade the signal-to-noise ratio for the detection of the smaller defects.

This invention is based on the observation that, by collecting scattered light in directions close to and at smaller angles to the specular reflection direction separately from light scattered at larger angles to the specular reflection direction and directing the light scattered at smaller angles to a different detector than the light scattered at larger angles, it is now possible to optimize the two or more detectors separately. Thus, two or more detectors are

used: at least a first detector for detecting the low intensity light scattered by smaller particles at larger angles to the specular reflection direction, and at least a second detector for detecting the high intensity light scattered by larger particles at smaller angles to the specular reflection direction. The first detector will not be seriously affected by scattering due to haze, since such scattering decreases rapidly at larger angles from the specular reflection direction.

The above concept is applicable even where the light beam for illuminating the surface to be inspected is at an oblique angle to the surface instead of being perpendicular to the surface and is also applicable for the differentiation, characterization and/or classification of different types of surface or near surface anomalies (referred to below simply as anomalies of surfaces or surface anomalies), including but not limited to anomalies such as scratches, slip lines, crystal originated particles (COPs) as well as contamination particles.

Thus, one aspect of the invention is directed towards an apparatus for detecting anomalies of surfaces, comprising means for directing a light beam towards a surface in a direction substantially normal to the surface, said direction defining an axis; means for causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and means for detecting light scattered by said surface around the axis, said directing and detecting means being substantially stationary. The detecting means includes at least two detectors: a first detector located to detect light scattered by the surface within a first range of collection angles from the axis and a second detector located to detect light scattered by the surface within a second range of

collection angles from the axis. The second range is different from the first range.

Another aspect of the invention is directed towards an apparatus for detecting anomalies of surfaces, comprising means for directing a light beam towards a surface to cause specular reflection in a direction defining an axis; means for causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and means for detecting light scattered by said surface around the axis, said directing and detecting means being substantially stationary. The detecting means includes at least a first detector located to detect light scattered by the surface within a first range of collection angles from the axis and at least a second detector located to detect light scattered by the surface within a second range of collection angles from the axis. The second range is different from the first range.

Yet another aspect of the invention is directed towards a method for detecting anomalies of surfaces, comprising the steps of directing a light beam towards a surface to cause specular reflection in a direction, said direction defining an axis; causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and detecting light scattered by said surface within at least a first range of collection angles from the axis by means of a first detector, and light scattered by the surface within at least a second range of collection angles from the axis by means of a second detector. The second range is different from the first range, said two ranges being preferably substantially stationary. In the preferred embodiment, the directing step is such that the axis is substantially normal to the surface.

Also in the preferred embodiment of the method and apparatus described above, the light detected by the at least first and second detectors within the at least two ranges of collection angles is substantially rotationally symmetric about the axis or near normal to the surface.

Some lasers may become unstable when light of significant intensity is reflected back towards the laser source. In such event, it may be desirable for the detectors to be slightly asymmetrically arranged about the axis so that they are substantially rotationally symmetric about a line which is at a small angle to the axis but which is nearly normal to the surface.

## Brief Description of the Drawing

Fig. 1 is a schematic view of a surface inspection system to illustrate the preferred embodiment of the invention.

Fig. 2 is a graphical plot of the scattered light intensity from a silicon surface, and from a large and a small PSL sphere placed on the surface to illustrate the invention.

Fig. 3 is a schematic view of a surface inspection system to illustrate an alternative embodiment of the invention.

## Detailed Description of the Preferred Embodiment

As shown in Fig. 1, the surface inspection system 10 may be used for inspecting anomalies on a surface 12. Surface 12 is illuminated by a substantially stationary illumination device portion of system 10 comprising a laser beam from a laser source (not shown). The laser beam 14 is passed through polarizing optics 16 of the device portion to cause the

laser beam to have the desired polarization state when used to illuminate surface 12. Laser beam 14 is then passed through a beam expander and aperture 18 and beam-forming optics 20 to expand and focus the beam 14'. The beam 14' is then reflected by a beam folding component 22 and a beam deflector 24 to direct the beam 14'' towards surface 12 for illuminating the surface. In the preferred embodiment, beam 14'' is substantially normal or perpendicular to surface 12, it being understood that this is not required and many of the advantages of the invention described herein are equally applicable where beam 14'' is at an oblique angle to surface 12.

In the preferred embodiment, beam 14'' is substantially perpendicular or normal to surface 12 and beam deflector 24 reflects the specular reflection of the beam from surface 12 towards component 22, thereby acting as a shield to prevent the specular reflection from reaching the detectors. The direction of the specular reflection is along line SR normal to surface 12. In the preferred embodiment where beam 14'' is normal to surface 12, this line SR coincides with the direction of illuminating beam 14'', where this common reference line or direction is referred to herein as the axis of system 10. Where beam 14'' is at an oblique angle to surface 12, the direction of specular reflection SR would not coincide with the direction of beam 14''; in such instance, the line SR indicating the direction of specular direction is referred to as the principal axis of the collection portion of system 10.

Light scattered by small particles are collected by mirror 38 and directed towards aperture 40 and detector 44. Light scattered by large particles are collected by lenses 32 and directed towards aperture 36 and detector 42. Large particles will also, of course, scatter light that is collected and directed to detector

44, and small particles will also scatter light that is collected and directed to detector 42, but such light is of relatively low intensity compared to the intensity of scattered light the respective detector is designed to detect.

To illustrate the preferred embodiment of the invention, Fig. 2 shows graphical plots 52, 54 of the scattered light intensity from a silicon surface, from a small PSL sphere of the order of 100 nanometers (nm) diameter placed on the surface and from a large PSL sphere of the order of 1 micron diameter placed on the surface. In reference to Fig. 1, the polar angle of Fig. 2 indicates the collection angle of the scattered light away from the axis SR of system 10. Thus, the intensity at a polar angle of zero degrees would indicate the intensity of light reflected or scattered by surface 12 or the PSL sphere along the axis SR of system 10 as shown in Fig. 1. As shown by curve 50, in Fig. 2, the light scattered by the silicon surface falls off rapidly away from the polar angle zero, where specular reflection occurs. The light scattered by the silicon surface away from the specular reflection direction is frequently due to haze; as shown in Fig. 2, light scattering due to haze falls off rapidly with increasing collector angles to the axis of the system. Specular reflection as well as scattered light at collection angles up to about 5° are deflected by deflector 24 and does not reach any one of the two detectors 42, 44. Light scattered at collection angles within the range of 5-20° from the axis SR of system 10 are collected by lenses 32 and deflected by beam deflector 34 towards an aperture 36, so that the portion of the beam that passes aperture 36 is detected by detector 42. Light scattered at collection angles in the range of about 25 to about 70 degrees are collected

by mirror 38 and focused towards an aperture 40 so that the light that passes through the aperture is detected by detector 44.

The angular distribution of light scattered by the small size PSL sphere is shown as the solid line curve 52 in Fig. 2. As shown in Fig. 2, small particles preferentially scatter at higher angles than a silicon surface. It is also known that small particles scatter at higher angles than larger particles. Whereas the intensity of scattering peaks at around 30-40° for a 100 nanometer PSL sphere, the scattered light intensity typically peaks at much lower scattering angles for large size spheres (about 1 micron diameter and greater). See curve 54 in Fig. 2. The device portion of system 10 for collecting and detecting scattered light from anomalies such as large particles is comprised of lenses 32, a folding mirror 34, aperture 36, and detector 42. Mirror 38, aperture 40, and detector 44 are adapted to detect scattered light from smaller particles, and form the device portion of system 10 for collecting and detecting scattered light from anomalies such as small particles and defects. Since larger particles typically scatter light at higher intensities compared to smaller particles, the detectors 42, 44 can be optimized separately, with detector 42 optimized for detecting large particles and detector 44 optimized to detect smaller particles. By using two different detectors for detecting scattered light within two different ranges of collection angles, each detector can be optimized for detecting the respective types of particles and the user is not forced to choose optimization for detecting one type of particle versus the other. Instead both detectors can be optimized to detect their respective types of particles simultaneously.

The meaning of "large" and "small" anomalies discussed above may be phrased in more general terms. In general, an anomaly is small if its dimensions are a fraction of the wavelength of the laser radiation used to illuminate the surface inspected. Thus, the plot of Fig. 2 shows the scattering from PSL spheres that are "large" and "small" with respect to visible light wavelengths. If radiation of other wavelengths are used, then the meaning of "large" and "small" anomalies will change according to such wavelengths.

If a single detector or detector arrangement is chosen to detect the light scattering from both large and small particles, a larger aperture stop must be employed to prevent near angle (near specular) surface scatter from surface 12 from reaching the detector. This would be necessary in order to maintain the sensitivity of the detector to low intensity scattering from smaller particles. A larger aperture stop would therefore decrease the sensitivity of the system towards light scattering by large particles and also to surface scattering characteristics at near specular angles of collection. This is undesirable. System 10 of Fig. 1 avoids such undesirable compromise. Since separate detectors 42, 44 are now employed, the design of both light collection and detection subsystems need not be constrained so that the range of collection angles for lenses 32 may be increased to include the near specular collection angles as well. While preferably lenses 32 collect light that are scattered in a range of 5-20°, such range may be extended to, for example, 3-25°. The larger ranges of collection angles would be useful for particle and defect characterization or classification in some applications.

As shown in Fig. 2, light scattering caused by haze falls off rapidly with increasing collection

angles, so that there is negligible light scattering caused by haze that is collected by mirror 38 and directed towards detector 44. This further enhances the sensitivity and accuracy of system 10 for detecting smaller anomalies. In the preferred embodiment, mirror 38 collects and focuses scattered light in the range of 25-70° from the axis of system 10 towards aperture 40 and detector 44. As indicated above, detectors 42, 44 may be optimized separately to have different intensity detection thresholds.

From the above description, it is seen that beam deflector 24 serves a dual function: to deflect the illuminating beam so as to provide beam 14'' and also acting as a stop to shield detectors 42, 44 from specular and near specular (or semi-specular) diffuse reflection. It should also be noted that the illumination portion and the detection device portions of system 10 are designed so that the illumination beam, in its entire path from the laser source until surface 12, does not pass through any lens or lens arrangement of the detection system. In the preferred embodiment shown in Fig. 1, this is implemented by placing the beam deflector 24 between lenses 32 and surface 12. An input aperture 38a in mirror 38 permits the illuminating laser beam to be passed from beam folding component 22 to beam deflector 24 so as to enable defector 24 to be placed between lenses 32 and surface 12. Mirror 38 is preferably ellipsoidal in shape and also preferably substantially rotationally symmetrical about axis SR of system 10, so that the same detection result can be obtained repeatedly irrespective of the relative orientation of surface 12 and of any defects thereon with respect to the illumination and the detection device portions of system 10. Thus the light detected by detectors 42, 44 within the two ranges of collection

angles is substantially rotationally symmetrical about the axis of system 10 upon such light scattering by surface 12. As noted above, to unavoid instability of some laser sources, it may be desirable for the two ranges of collection angles to be rotationally symmetrical about a line that is at a small angle (e.g. 1 degree) to the axis of system 10 instead. Such arrangement is also included when it is indicated herein that the light detected by two or more detectors within two or more ranges of collection angles is substantially rotationally symmetrical about the axis of the detection system.

Fig. 3 is a schematic view of a surface inspection system 100 to illustrate an alternative embodiment of the invention. The system 100 is similar to system 10 of Fig. 1 except that the bottom portion 38a of mirror 38' has a different curvature than the remaining portion, so that where the remaining portion focuses the light scattered by surface 12 towards aperture 40 and detector 44, portion 38b has a different focal point and focuses the scattered light impinging on it towards a beam turning component 102 that reflects such light towards an aperture 104 and detector 106 for detection. Portion 38b preferably collects and focuses light in the range of about 65 to 85 degrees from axis SR towards aperture 104 and detector 106. The remaining portion of mirror 38' collects and focuses light in the range of about 25 to 60 degrees from axis SR towards aperture 40' and detector 44. The lenses 32' collects and focuses light in the range of about 5 to 20 degrees (or even 3 to 25 degrees) from axis SR towards aperture 36' and detector 42. The use of three sets of light collection optics and detectors to separately detect the scattered light in smaller ranges of angles from axis SR may be advantageous for some applications. Obviously,

mirror 38' may have more than two portions having different focal points, in order to separately detect the scattered light in more than three smaller ranges of angles from axis SR. Such and other variations are within the scope of the invention.

Rotational and translational movement of surface 12 is caused in a conventional manner so that beam 14'' scans the surface along a spiral path. Thus as shown in Fig. 3, the semiconductor wafer 11 having surface 12 thereon may be supported by a supporting disk 72 which is connected to a shaft 112 having axis 74 of a rotary motor 114 which is in turn fixed to a linear translation stage 116, driven by a translation motor 118. The rotary and translation motors are controlled in a coordinated manner as known to those skilled in the art to cause simultaneous rotational and translational movement of surface 12 so that beam 14'' would trace a spiral path on surface 12. Surface 12 of Fig. 1 may be caused to travel in the same manner so that beam 14'' scans surface 12 along a spiral path.

In operation, a light beam such as beam 14'' is directed towards surface 12 in a specified direction or angle of incidence, causing specular reflection along a direction defining an axis. Rotational and translational movement of the surface is caused so that the beam scans the surface along a spiral path. Light scattered by the surface within the first range of collection angles from the axis is detected by means of a first detector. Light scattered by the surface within the second range of collection angles from the axis is detected by means of a second detector, where the two ranges of collection angles are different. Preferably, the two ranges of collection angles are substantially stationary. Preferably, the axis is substantially normal to the surface.

Preferably, the light beam 14'' illuminates an elliptical spot on the surface 12, where the long axis of the spot has dimensions in the range of 40 to 400 microns and the short axis has dimensions in the range of 10 to 50 microns. By illuminating only a small spot of surface 12, sensitivity of the system will be improved and signal-to-noise ratio will be enhanced.

While the invention has been described above by reference to the preferred embodiment, it will be understood that various changes and modifications may be made without departing from the scope of the invention which is to be defined only by the appended claims. For example, while only one detector has been shown for each of the two detectors 42, 44, it will be understood that an array of detectors may be used for each of the two detector locations 42, 44. Additional apertures or aperture stops may be employed in the detection and illumination portions of system 10 than as shown in Fig. 1. The illumination beam and the collector light may also be passed through more or fewer lenses or mirrors of different optical arrangements than as shown in Fig. 1. All such variations are within the scope of the invention. The system described is also advantageous for differentiating between scratches, slip lines and COPs, since one type of such defects may scatter light at a larger angle to the axis compared to another type of such defects.

WHAT IS CLAIMED IS:

1. An apparatus for detecting anomalies of surfaces, comprising:

means for directing a light beam towards a surface in a direction substantially normal to the surface, said direction defining an axis;

means for causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and

means for detecting light scattered by said surface around the axis, said directing and detecting means being substantially stationary;

said detecting means including at least two detectors, said at least two detectors comprising a first detector located to detect light scattered by the surface within a first range of collection angles from the axis and a second detector located to detect light scattered by the surface within a second range of collection angles from the axis, said second range being different from the first range.

2. The apparatus of claim 1, said detecting means including at least one lens for collecting light to be detected, said directing means directing light towards the surface along an illumination path that does not pass through said at least one lens.

3. The apparatus of claim 1, said detecting means including a first aperture for the first detector and a second aperture for the second detector, said first and second apertures having different aperture sizes.

4. The apparatus of claim 1, said directing means including at least one beam expander for shaping and focusing the light beam and at least one illumination aperture.

5. The apparatus of claim 1, said first range of angles being about 3 to 25 degrees, and said second range being about 25 to 70 degrees.

6. The apparatus of claim 1, said detecting means including at least three detectors located to detect light scattered by the surface within at least a first, second and third range of collection angles from the axis, said first range of angles being about 3 to 25 degrees, and said second range being about 25 to 65 degrees, and said third range being about 65 to 85 degrees.

7. The apparatus of claim 1, said directing means including a beam deflector for deflecting light from a light source towards the surface, said deflector also shielding the first and second detectors from specular and semi-specular reflection.

8. The apparatus of claim 7, said detecting means including at least one lens for collecting light to be detected, said deflector being located between the surface and the at least one lens.

9. The apparatus of claim 1, said two detectors having different intensity detection thresholds.

10. The apparatus of claim 1, said second detector including a collection mirror and a photo-

sensitive device, said mirror being substantially rotationally symmetrical about said axis.

11. The apparatus of claim 1, said detector means being such that the light detected by the first and second detectors within the two ranges of collection angles is substantially rotationally symmetrical about the axis.

12. An apparatus for detecting anomalies of surfaces, comprising:

means for directing a light beam towards a surface, causing a specular reflection in a direction defining an axis;

means for causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and

means for detecting light scattered by said surface around the axis, said directing and detecting means being substantially stationary;

said detecting means including at least two detectors, said at least two detectors comprising a first detector located to detect light scattered by the surface within a first range of collection angles from the axis and a second detector located to detect light scattered by the surface within a second range of collection angles from the axis, said second range being different from the first range.

13. The apparatus of claim 12, said detecting means including at least one lens for collecting light to be detected, said directing means directing light towards the surface along an illumination path that does not pass through said at least one lens.

14. The apparatus of claim 12, said detecting means including a first aperture for the first detector and a second aperture for the second detector, said first and second apertures having different aperture sizes.

15. The apparatus of claim 12, said directing means including at least one beam expander for shaping and focusing the light beam, and at least one illumination aperture.

16. The apparatus of claim 12, said first range of angles being about 3 to 25 degrees, and said second range being about 25 to 70 degrees.

17. The apparatus of claim 12, said detecting means including at least three detectors located to detect light scattered by the surface within at least a first, second and third range of collection angles from the axis, said first range of angles being about 3 to 25 degrees, and said second range being about 25 to 65 degrees, and said third range being about 65 to 85 degrees.

18. The apparatus of claim 12, said directing means including a beam deflector for deflecting light from a light source towards the surface, said deflector also shielding the first and second detectors from specular and semi-specular reflection.

19. The apparatus of claim 18, said detecting means including at least one lens for collecting light to be detected, said deflector being located between the surface and the at least one lens.

20. The apparatus of claim 12, said two detectors having different intensity detection thresholds.

21. The apparatus of claim 12, said detector means being such that the light detected by the first and second detectors within the two ranges of collection angles is substantially rotationally symmetrical about the axis.

22. A method for detecting anomalies of surfaces, comprising the steps of:

directing a light beam towards a surface, causing a specular reflection in a direction, said direction defining an axis;

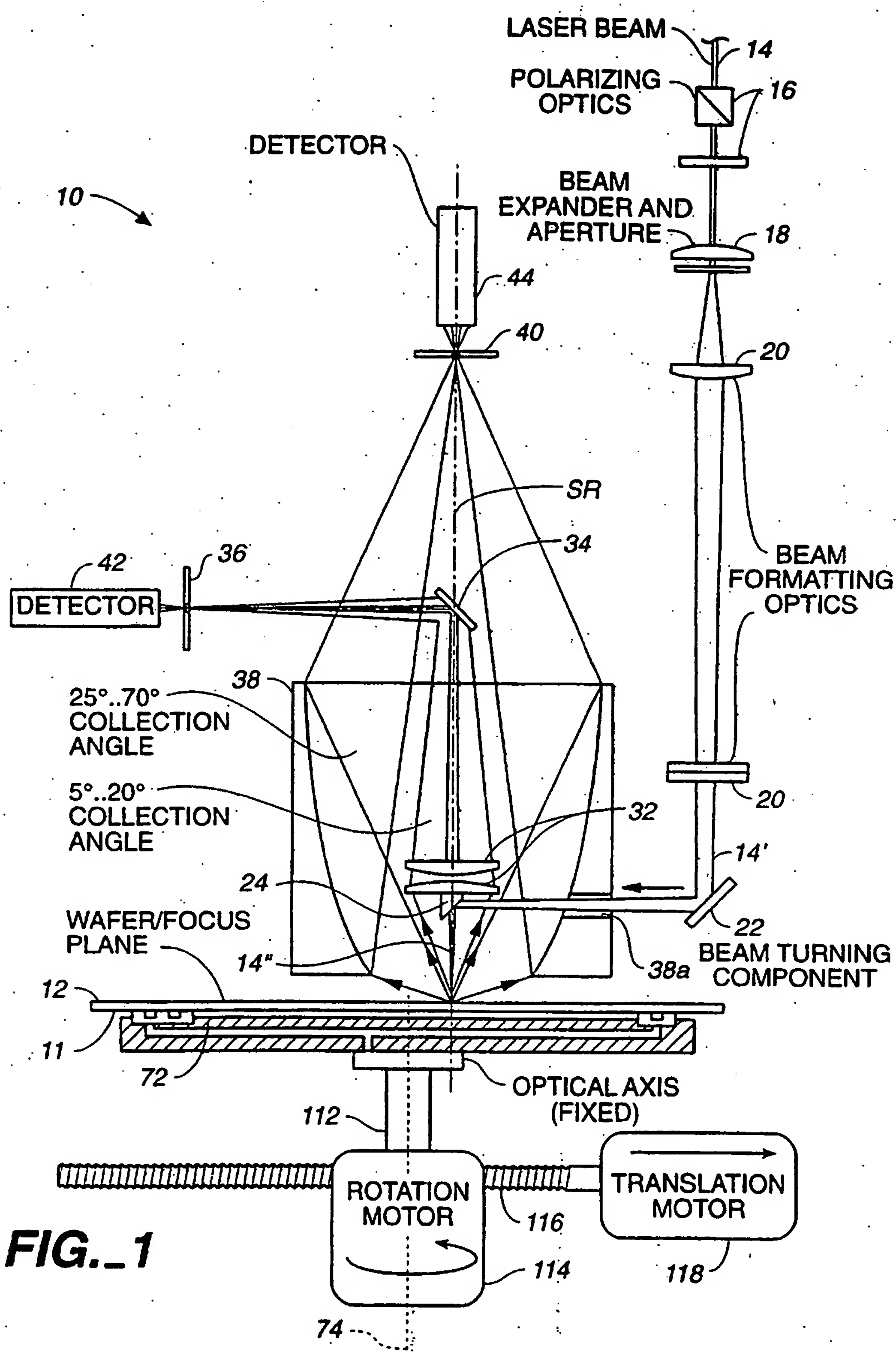
causing rotational and translational movement of the surface, so that the beam scans the surface along a spiral path; and

detecting light scattered by said surface within at least a first range of collection angles from the axis by means of a first detector, and detecting light scattered by the surface within at least a second range of collection angles from the axis by means of a second detector, said second range being different from the first range, said two ranges being substantially stationary.

23. The method of claim 22, said directing step being such that the axis is substantially normal to the surface.

24. The method of claim 23, said detecting step being such that the light detected by the first and second detectors within the two ranges of collection

substantially angles is rotationally symmetrical about the axis.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SR
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BEAM FORMATTING OPTICS
42
36
DETECTOR
38
25°..70° COLLECTION ANGLE
5°..20° COLLECTION ANGLE
20
32
14'
24
22
WAFER/FOCUS PLANE
14"
38a
BEAM TURNING COMPONENT
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OPTICAL AXIS (FIXED)
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ROTATION MOTOR
TRANSLATION MOTOR
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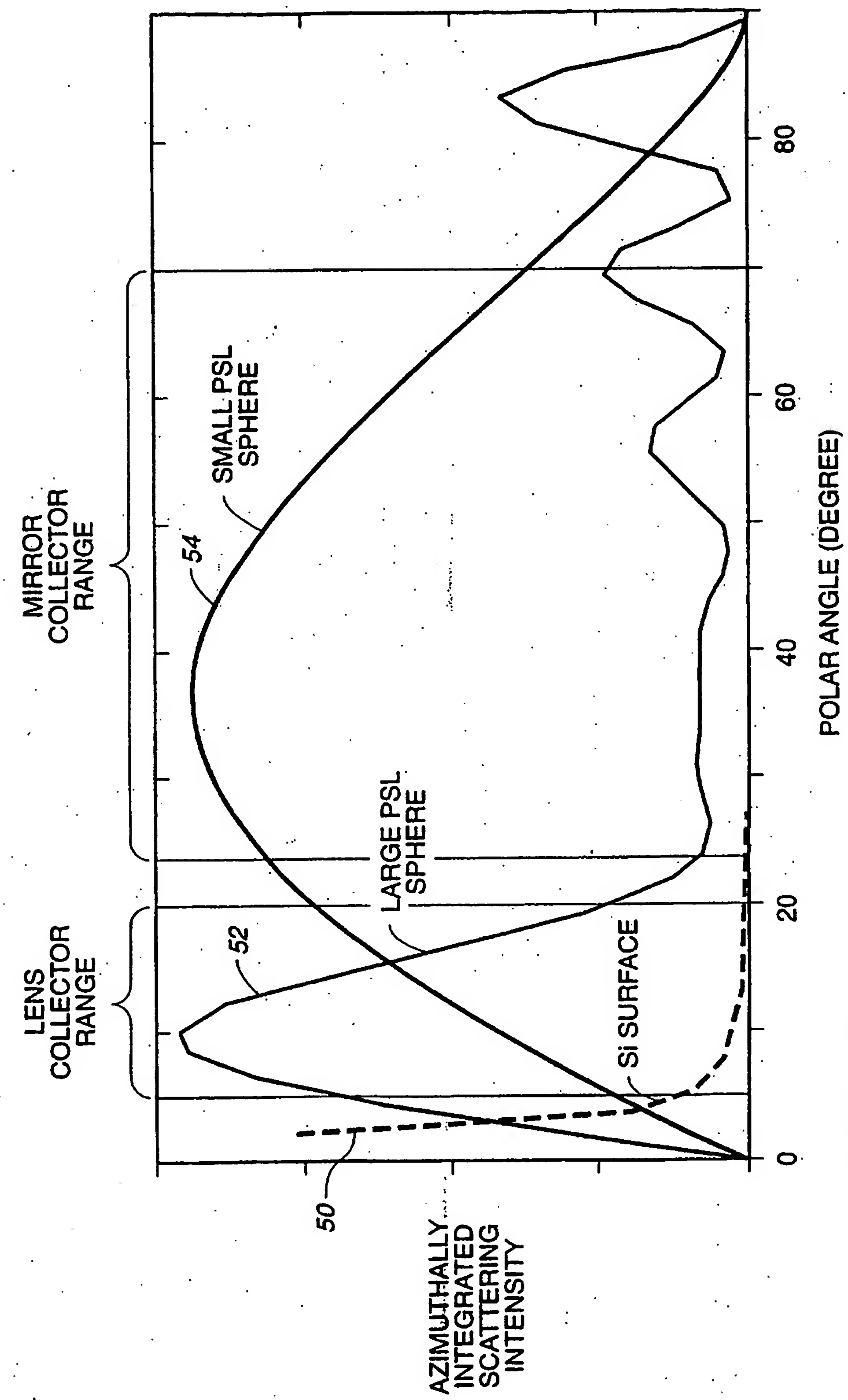
114
118
74

FIG._1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LENS COLLECTOR RANGE
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54
LARGE PSL SPHERE
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Si SURFACE
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20
40
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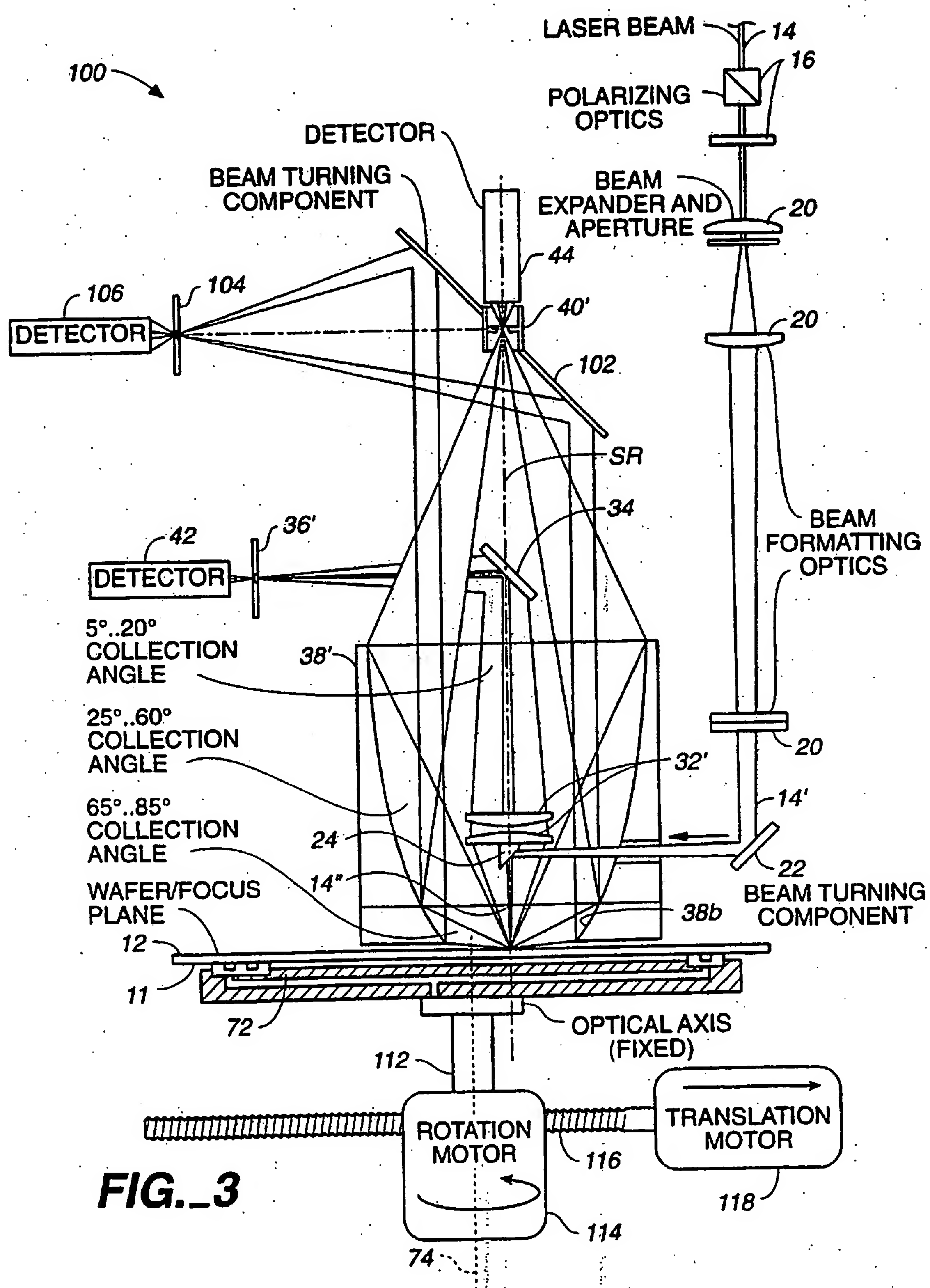
FIG._2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BEAM TURNING COMPONENT
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38b
WAFER/FOCUS PLANE
12
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OPTICAL AXIS (FIXED)
112
ROTATION MOTOR
TRANSLATION MOTOR
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118
114
74

FIG._3

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/15354

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :G01N 21/47
US CL : 356/237
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 356/237, 338, 343, 371, 446

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>---<br>Y | US 4,794,265 A (QUACKENBOS et al) 27 December 1988), figures 1 and 4. | 1, 2, 8, 11-13,19,21-24<br>---<br>3-7,9,10,14-18,20 |
| Y | US 5,406,367 A (SOPORI) 11 APril 1995, figure 1. | 3-7,9,10, 14-18,20 |
| Y | JP 63-140904 A (SASAKI) 13 June 1988, figure 1 | 10 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 17 DECEMBER 1996 | 27 DEC 1996 |

| Name and mailing address of the ISA/US | Authorized officer |
|---|---|
| Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231 | RICHARD A. ROSENBERGER |
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